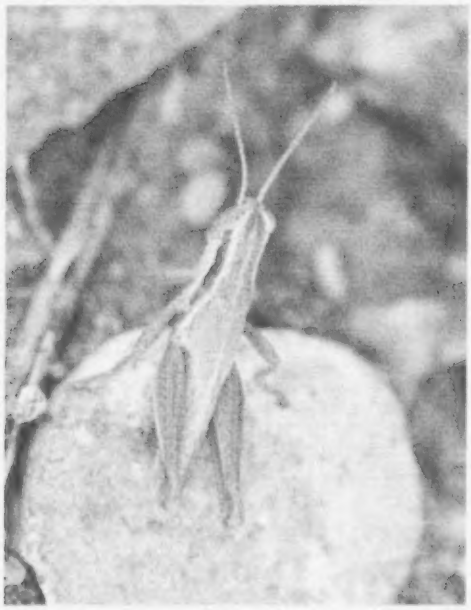
COSEWIC
Assessment and Status Report

on the

Greenish-white Grasshopper
Hypochlora alba

in Canada



SPECIAL CONCERN
2012

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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COSEWIC would like to acknowledge Dr. Dan L. Johnson for writing the status report on the Greenish-white Grasshopper, *Hypochlora alba*, in Canada, prepared under contract with Environment Canada. This report was overseen and edited by Dr. Paul Catling, Co-chair of the COSEWIC Arthropods Specialist Subcommittee.

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Greenish-white Grasshopper — Provided by author.

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COSEWIC
Assessment Summary

Assessment Summary – November 2012

Common name
Greenish-white Grasshopper

Scientific name
Hypochlora alba

Status
Special Concern

Reason for designation
This distinctive grasshopper is restricted to dry mixed grass prairie in southernmost Saskatchewan and southwestern Manitoba. Most of the Canadian population is found in only a few sites with many sites having very small populations. There is evidence that there has been a decline in the western part of the range. A number of threats have been documented including conversion to tame pasture, pesticide use and overgrazing. Re-establishment of lost populations and rescue effect are limited by the fact that this species is mostly flightless, although some Canadian habitat is continuous across the border.

Occurrence
Alberta, Saskatchewan, Manitoba

Status history
Designated Special Concern in November 2012.

COSEWIC
Executive Summary

Greenish-white Grasshopper
Hypochlora alba

Wildlife Species Description and Significance

Hypochlora alba is usually referred to as the Greenish-white Grasshopper in Canada. In the United States its common name is the Sagebrush Grasshopper, Cudweed Sagewort Grasshopper, or Cudweed Grasshopper, because it is found in close proximity to its principal foodplant, White Sagebrush. It is a small, flightless grasshopper, with late instars and adult males typically 1.1 to 1.5 cm in length and adult females up to 2.0 cm. The Greenish-white Grasshopper is in the spur-throated (also called spine-breasted) subfamily of the short-horned grasshoppers. The body is a light, milky green colour with small green spots (speckles), and pale white longitudinal stripes.

Distribution

The Greenish-white Grasshopper inhabits relatively undisturbed dry mixed grass prairie of the Great Plains of North America. Its distribution extends in a narrow grassland area from the southern Canadian Prairies to northern Texas, apparently restricted to the areas within the distribution of its food plant, White Sagebrush, but only at lower elevations where it can complete its life cycle and survive to reproduce.

The distribution of the Greenish-white Grasshopper in Canada historically includes southeastern Alberta, southern Saskatchewan north to the Great Sand Hills, and extreme southwestern Manitoba. After 1980, a decline was noticed in number of sites in the west.

Habitat

The habitat of the Greenish-white Grasshopper consists mainly of pastures and grassland in the mixed grass or dry mixed grass ecoregions where the principal food plant, White Sagebrush (and in some cases secondary food plants) occur; usually such sites are found in locations throughout the northern Great Plains and southern Canadian Prairies. Habitats may include livestock pastures and uncultivated sites along roadsides, fencelines, streams, disturbed land, or shelterbelts. White Sagebrush is a terpenoid-containing forb (Family Asteraceae), and is very rarely used as food by other insects. Plants typically reach about 20 to 50 cm high, with blue flowers and silver foliage and stems. The plant is used as food for all stages of the Greenish-white Grasshopper, and is therefore a critical requirement for breeding. An analysis of threats suggests a continuing decline in habitat.

Biology

Greenish-white Grasshoppers overwinter as eggs in small egg pods laid near the surface of soil, near the food plant. The embryo overwinters with an incomplete degree of development, and continues growth when soil warms. It hatches later than most other grasshoppers, typically appearing in mid-July in Canada. Growth proceeds through 5 immature stages, and adults generally appear in August. By mid-August, populations are generally around 80% adult. As with other grasshopper species, behavioural adaptations have apparently allowed some expansion of geographic distribution. For example, in late instar and adult stages, Greenish-white Grasshoppers may sun themselves by sitting on the food plant perpendicular to incoming sunlight, often raising hind legs away from the body, thus raising the body temperature.

Population Sizes and Trends

By comparison with other species with similar range and based on the literature, Greenish-white Grasshopper was thought to be common at its sites in Canada until 1980, after which it was rarely seen, and after which a decline is thought to have occurred. This decline is well documented in some areas. For example, it was previously found in Onefour, Alberta, according to collections taken in the late 1970s and early 1980s; however, it was not found in these same locations during sampling between 1984 and 2002. During 2000-2006, in a large rangeland area near Onefour, a sample of over 10,000 grasshoppers was studied but contained no Greenish-white Grasshoppers. During 2003-2007, collections indicated a general decline in Canada. However, field sampling in August 2010 suggested that this species has recovered to discernable levels in some eastern portions of the range. The increase of the population in Canada may have resulted from relatively cool and moist condtions.

Threats and Limiting Factors

An analysis of six poorly documented minor threats (including: 1) Conversion to tame pasture with Crested Wheatgrass; 2) Warmer and moister conditions; 3) Pesticide use and drift; 4) Dams, reservoirs, irrigation; 5) Oil and gas exploration; and 6) Heavy grazing leading to takeover by invasive plants) suggests a continuing medium-level threat impact on the habitat.

Protection, Status, and Ranks

COSEWIC assessed this species as Special Concern in November 2012. Currently, this insect species and the food plant habitat have no protection or conservation status.

TECHNICAL SUMMARY

Hypochlora alba
Greenish-white Grasshopper — Criquet de l'armoise
Range of occurrence in Canada (province/territory/ocean): SK, MB, AB

Demographic Information

Generation time	One generation per year; all stages observed
Is there an observed continuing decline in number of mature individuals? *1980-2006. No more. Decline apparently reversed in 2008-2010.*	Unknown
Estimated percent of continuing decline in total number of mature individuals	Unknown
Percent reduction in total number of mature individuals over the last 30 years *Estimated decline from 1980 to 2006 was > 90%. Unexpectedly recovered 2008-2010.*	Unknown
Percent reduction or increase in total number of mature individuals over the next 10 years *The population seems to have resurged; although low it is not alarmingly so.*	Unknown
Percent reduction in total number of mature individuals over any period, over a time period including both the past and the future. *Estimated decline from 1980 to 2006 > 90%. Unexpectedly recovered 2008-2010.*	Unknown
Are the causes of the decline clearly reversible and understood and ceased? *Weather and management impacts on the food plant may be key factors.*	Unknown
Are there extreme fluctuations in number of mature individuals? *Changes in abundance could be due to natural fluctuations or declines.*	Possibly

Extent and Occupancy Information

Estimated extent of occurrence	> 43,000-46,000 km²
Index of area of occupancy (IAO) *Based on known and historic sites in 2010, and potential sites, for maximum of 100 sites and a 2X2 km grid.*	100 - 400 km².
Is the total population severely fragmented? It seems likely that the very low population levels may be a result of natural fluctuation or at least are not well understood	Possibly

Number of locations There are 14 recently confirmed sites and 8 unconfirmed historical sites. It is also possible that other sites exist in the extent of occurrence, but unlikely outside that area (given the results of recent directed search). Within the area not all potential sites are likely to contain a population based on the recent surveys, so fewer than 200 additional sites are expected and experts (Dan Johnson and associates) suggest 60 so 100 seems to be a reasonable figure. The known sites are influenced by different threats acting independently so there are as many locations as sites, although the overall medium threat impact level suggests a generally declining habitat.	14-200
Is there a continuing decline in extent of occurrence? Recovery seems to be underway, related to food plant and weather.	No.
Is there a continuing decline in index of area of occupancy? Food plant seems to have remained at low levels. Recovery underway.	No.
Is there a continuing decline in number of populations? Decline was severe, but seems to have reversed. Low population levels may persist locally.	No.
Is there a continuing decline in number of locations?	No.
Is there a continuing decline in [area, extent and/or quality] of habitat?	Yes.
Are there extreme fluctuations in number of populations? Small foci may persist if food plant remains available.	Unknown
Are there extreme fluctuations in number of locations?	Unknown
Are there extreme fluctuations in extent of occurrence?	Unknown
Are there extreme fluctuations in index of area of occupancy?	Unknown

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Current typical numbers per 1-ha site:	1000
Total	Estimate increased to well over 100,000 in Canada, due to the rapid reproductive rate

Quantitative Analysis

Extinction in the wild is probable.	Not available

Threats (actual or imminent, to populations or habitats)

There are no major well documented threats but a number of poorly documented minor threats including: 1) Conversion to tame pasture with Crested Wheatgrass; 2) Warmer and moister conditions; 3) Pesticide use and drift; 4) Dams, reservoirs, irrigation; 5) oil and gas exploration; and 6) heavy grazing leading to takeover by invasive plants.
Although there is little definite information on these threats, it seems reasonable to conclude that over a 10-year period all operate and all affect 1-10% of the total population (scope = small), and also that the damage is at least a 1 - 10 % reduction to that portion that is affected (severity = slight). This leads to an overall threat impact of "medium" which is likely a minimum.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? US populations were sampled during the study and seem not to be at risk, with roadside and pasture metapopulations more frequent and dense.	
Is immigration known or possible?	Unknown and unlikely
Would immigrants be adapted to survive in Canada?	Possibly
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Status History

COSEWIC: Designated Special Concern in November 2012.

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Special Concern	not applicable
Reasons for designation: This distinctive grasshopper is restricted to dry mixed grass prairie in southernmost Saskatchewan and southwestern Manitoba. Most of the Canadian population is found in only a few sites with many sites having very small populations. There is evidence that there has been a decline in the western part of the range. A number of threats have been documented including conversion to tame pasture, pesticide use and overgrazing. Re-establishment of lost populations and rescue effect are limited by the fact that this species is mostly flightless, although some Canadian habitat is continuous across the border.	

Applicability of Criteria

Criterion A: Not applicable. Decline not over past 10 years and not quantified.
Criterion B: Not applicable. The index of area of occupancy is low (100-400km^2) and based on estimates and the available information, most of the total Canadian population is only in a few sites with many sites having very small populations.
Criterion C: Not applicable since population sizes are unknown.
Criterion D: Not applicable. Population size unknown and IAO and number of locations beyond limit.
Criterion E: None.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2012)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

Greenish-white Grasshopper

Hypochlora alba

in Canada

2012

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Kingdom	Animalia – Animal, animaux, anim
Phylum	Arthropoda – Artrópode, arthropodes, arthropods
Subphylum	Hexapoda – hexapods
Class	Insecta – insects, hexapoda, inseto, insectes
Subclass	Pterygota – insects ailés, winged insects
Infraclass	Neoptera – modern, wing-folding insects
Order	Orthoptera – grasshoppers, locusts, criquet-locustes, locustes, sauterelles, gafanhoto, grilo, crickets, katydids
Suborder	Caelifera
Infraorder	Acrididea
Superfamily	Acridoidea MacLeay, 1819
Family	Acrididae MacLeay, 1819 – grasshoppers, short-horned grasshoppers
Subfamily	Melanoplinae
Genus	Hypochlora Brunne
Species	*Hypochlora alba* (Dodge, 1876), Greenish-white Grasshopper, Criquet de l'armoise

Hypochlora alba (Dodge 1876) is usually referred to as the Greenish-white Grasshopper in Canada (Figure 1). In the USA, the common name is Sage Grasshopper, Cudweed Sagewort Grasshopper, or Cudweed Grasshopper, because they are found in close association with their principal foodplant, *Artemisia ludoviciana* Nutt. (Prairie Sagewort or White Sagebrush) (Figures 2 & 3). This association is well known and has been documented in early studies of their distribution and life history (e.g., Criddle 1935; Knutson 1982; Mulkern 1980). No subspecies are recognized.

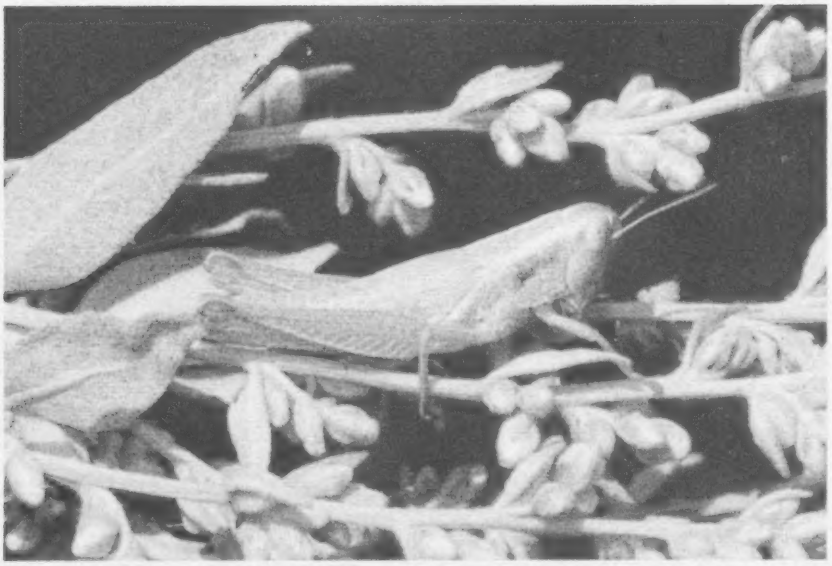

Figure 1. The Greenish-white Grasshopper, *Hypochlora alba*, on its foodplant. Photo by D. Johnson.

Figure 2. Typical patch of White Sagebrush where low numbers of Greenish-white Grasshopper were found in 2010. Photo by D. Johnson.

Figure 3. Cryptic colouration of the Greenish-white Grasshopper. Photo by D. Johnson.

Morphological Description

It is a small, flightless grasshopper, with late instars and adult males typically 1.1 to 1.5 cm in length and adult females up to 2.0 cm (in Canada; D. Johnson unpublished data). *Hypochlora alba* is in the spur-throated (also called spine-breasted) subfamily of the Short-horned Grasshoppers (Orthoptera: Acrididae: Melanoplinae). The ventral spur or spine, posterior to the mouthparts, is clearly visible. The forewings in the adult are reduced to short bracts, only about 0.23 to 0.25 as long as the body, and covering about 0.34 to 0.38 of the abdomen directly behind the pronotum (shield on top of the thorax). The body is a light, milky green colour with small green spots (speckles), and pale white longitudinal stripes. The median carina (central, dorsal, longitudinal ridge on the thorax, easily seen from above) is clearly visible, but is low, slim, and milky in colour. The pronotum on both sides of the median carina is green, and a white stripe on each side of the body gives the appearance of four light green longitudinal stripes from above. The antennae are long and typically light green in the immature stages and reddish-brown, grey and tan in adults of Canadian populations (sometimes greener in USA populations). More than 20 antennal segments can easily be counted. All femora of this species are delicate and light green, but may be darker green than the body. The eye is grey or tan, with small light green and grey speckles. Nymphs (see Pfadt 1996 for illustrations) are similar to adults but are speckled. The eggs are laid in the soil in tan-coloured pods 1.8 mm long, each containing 8-12 eggs (illustrated by Pfadt 1996).

Hypochlora alba might be mistaken for two different species: *Hesperotettix viridis* and *Chorthippus curtipennis*. *Hypochlora alba* is distinguished from *Hesperotettix viridis* (Purple-striped Grasshopper in Canada, Snakeweed Grasshopper in the USA), another small, green melanopline species found in the same habitat, mainly through colour differences. *H. viridis* is the more colourful of the two, with pink or salmon on the posterior tips of the hind femora and covering most of the length of the anterior 4 femora. *Hypochlora viridis* also has antennae that are usually pink or reddish in Canada (but darker or even black in some USA populations), and high-contrast white stripes on the pronotum, mesothorax, and edges of the hind femora. The hind tibia of *H. viridis* are usually teal or turquoise, but the hind tibia of *H. alba* are pale greenish white, similar to the hind femora.

Another green species that might be confused with *H. alba* is *Chorthippus curtipennis*, the Marsh Meadow Grasshopper, which may appear green on the pronotum, but is mainly straw-yellow, especially on the hind legs. *Chorthippus curtipennis* is a slant-faced grasshopper, and therefore lacks the prominent spur in the "throat" area, thus distinguishing it (Johnson 2002, 2003). Adult female *C. curtipennis* have long wings, often yellow, tan or straw-coloured, extending beyond the tip of the abdomen; males have short wings. *Hypochlora alba* has small, short wings, which usually do not reach the middle of the abdomen. Finally, the behaviour of *H. alba* is also distinct from these other two species; while the latter are very active jumpers, *H. alba* usually jump only short distances when disturbed from the vicinity of their common food plant, White Sagebrush, and often quickly cease jumping and rest in low vegetation.

Population Spatial Structure and Variability

Populations and subpopulations of *H. alba* are dependent on the distribution and size of patches of the obligate food plant, White Sagebrush. Typically, these vary in size from 5 square metres to patches as large as several hectares that are 10 to 20% covered with White Sagebrush. Variation within and between populations has not been studied. Based on the fact that the species is flightless and habitat is patchy, one might conclude that the population may be composed of subpopulations that are connected at the local scale (0.5 – 2 km) but isolated regionally.

Designatable Units

The subpopulations of *H. alba* are patches of the obligate food plant, White Sagebrush. There are no studies of the genetic diversity and relatedness of subpopulations. The potential geographic region in which these patches may occur falls on a line from approximately Melita, Manitoba, west to the Alberta border, with a central zone about 40 km wide. Around 5% of this area may have the appropriate food plant and climatic conditions, although *H. alba* populations were largely absent during 1980-2006. This Canadian range, although not continuous, is not characterized by major disjunctions and all subpopulations are within the prairie region and considered as a single designatable unit.

Special Significance

Hypochlora alba has never had any significant pest status attributed to it in Canada or the USA. In theory, if *A. ludoviciana* were desired in a grassland ecosystem and *H. alba* was abundant, some defoliation and suppression could have a positive impact on rangeland, but damage is usually very light. Minor feeding on other plant species, mainly the common composite *A. frigida* Willdenow (Fringed or Pasture Sage), and in rare cases *A. cana* Pursh (Silver Wormwood), could also have a small positive value in range management. However, because of its very low population density in Canada, there are no cases in which feeding damage to food plants indicated potential value of *H. alba* as a biological control agent.

Hypochlora alba is suspected of being a potential food item for certain songbirds, although observations of hundreds of feeding events and collection of food samples from two years of study in an area within the known or suspected distribution of *H. alba* did not record a single case of this species in the diet of songbirds, probably because of a combination of very low abundance and cryptic colouration (Martin *et al.* 1998, 2000).

DISTRIBUTION

Global Range

The distribution of the Greenish-white Grasshopper, *H. alba* (Figure 4), extends in a grassland area from the southern Canadian Prairies to northern Texas. It is apparently restricted to certain areas within the broader distribution of its food plant, White Sagebrush. For example, it occurs only at lower elevations where it can complete its life cycle and survive to reproduce. It is also absent from extensive areas within the range shown due to conversion of grasslands to agriculture.

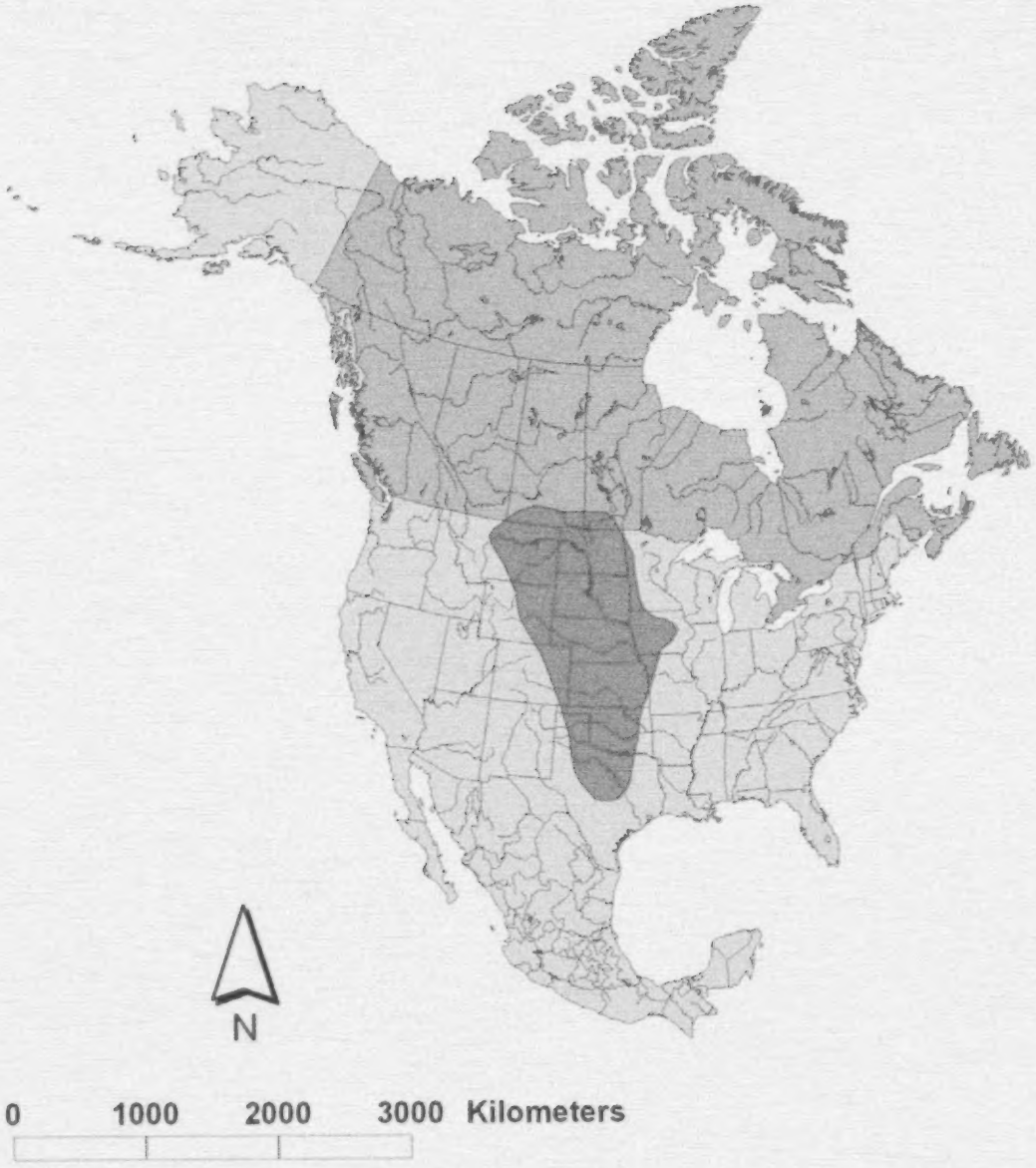

Figure 4. Global distribution of *Hypochlora alba*. Redrawn from Capinera *et al.* (2004).

Canadian Range

The Canadian distribution of *Hypochlora alba* is illustrated in Figure 5a. Based on collected specimens, the generally accepted Canadian distribution of *H. alba* in Canada until around 1985 was a narrow zone of southern Alberta, Saskatchewan and Manitoba, along the US border (Vickery and Kevan 1985) (Figure 5a). Previously known localities included mixed grassland and dry mixed grassland (short grass) of southeastern Alberta, south-central and southeastern Saskatchewan, southwestern Manitoba, and apparently some sites nearer the cities of Winnipeg and Brandon. After 1980 and until 2008, a decline was noticed in number of sites and overall distribution but a few additional sites were discovered including those at Medicine Hat, east of the Great Sand Hills, within the Great Sand Hills, at Big Muddy and in the West Block of Grasslands National Park (Figure 5a). Population size at some sites was very low suggesting continuing decline (see also **Habitat Trends** and **Population Sizes and Trends**). After 2008, it appears to have recovered to a degree, especially in the east (Figures 5b & c) and some additional sites were added in the directed search in 2010 (Figure 5a).

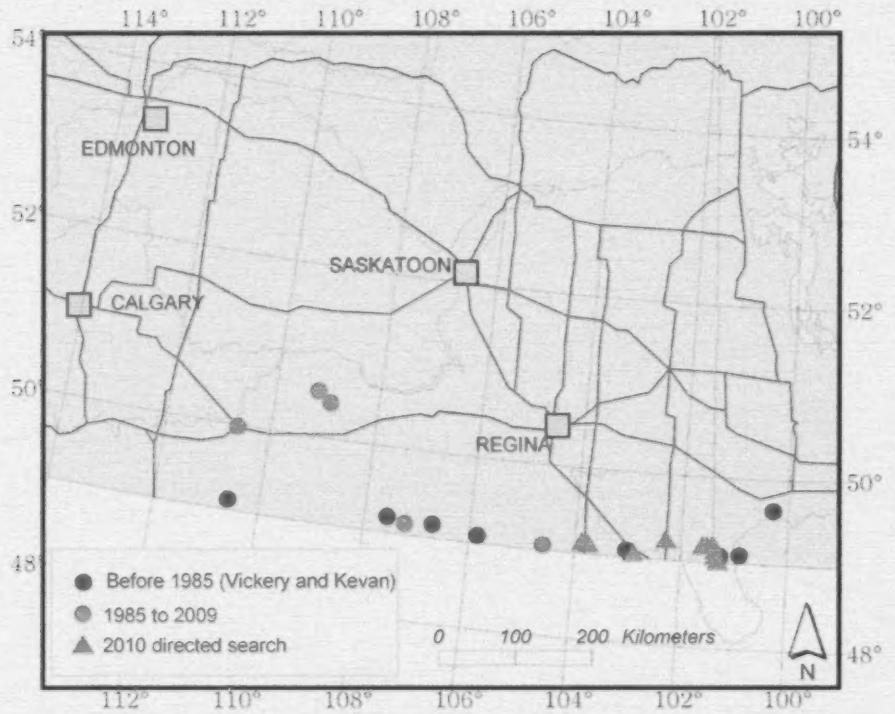

Figure 5a. Sites from which the Greenish-white Grasshopper was known prior to 1985 (excepting sites near Winnipeg and Brandon, based on Vickery and Kevan, 1985, Map 117, p. 338), but rare during approximately 2000-2007. Historical sites reported near to the cities of Winnipeg and Brandon are not shown on this map which otherwise includes all Canadian locations.

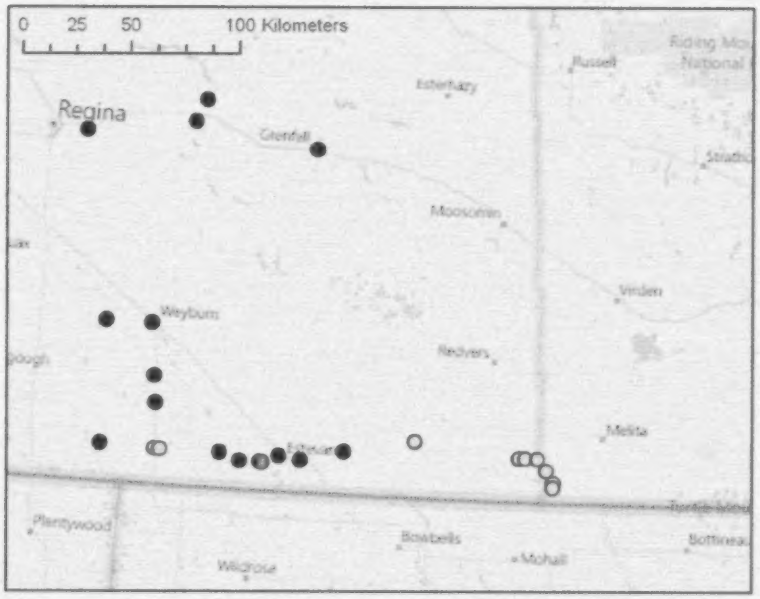

Figure 5b. Map illustrating the locations of the sites at which *H. alba* was found in 2010 (suggesting increase during 2008-2010). Black: none; Green: low; Red: high.

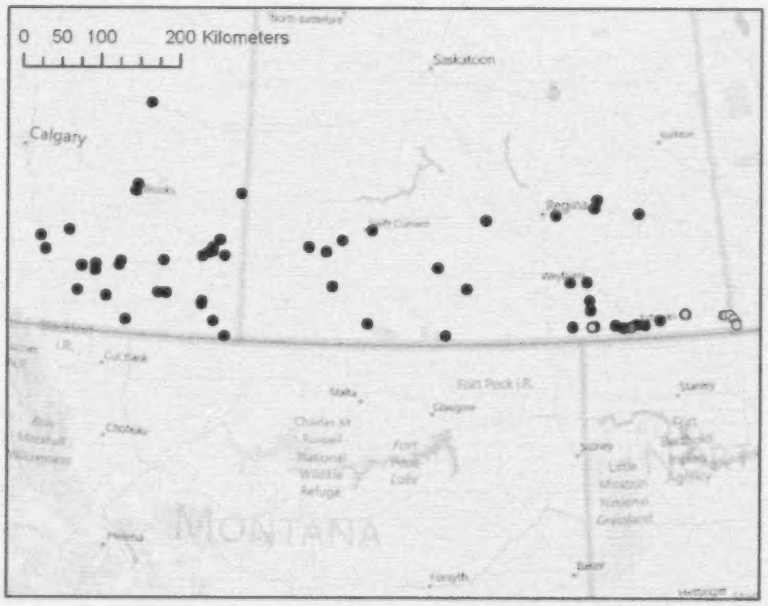

Figure 5c. The wider range of searches for *H. alba* in 2010. Key locations are shown; additional field site visits were made between these sites typically within 3 km of major roads and highways. Black: none; Green: low; Red: high. Note: sites near Grasslands National Park were searched in 2002-2006 but not 2010.

Since it exists at extremely low population levels in some sites, it may not be extirpated from others where it has been undetectable for many years, these low population levels representing extreme natural fluctuations. As a result the extent of occurrence (EO) calculations and the upper index of area of occupancy (IAO) calculations include all historic occurrences. The EO is 43,000 – 46,000 km^2 and the IAO is 100-400 km^2.

There are 14 recently confirmed sites and 8 unconfirmed historical sites (Figure 5a). It is also possible that other sites exist in the extent of occurrence, but unlikely outside that area (given the results of recent directed search). Within the area not all potential sites are likely to contain a population based on the recent surveys, so fewer than 200 additional sites are expected. Experts have suggested a maximum of 60 additional sites. The known sites are influenced by different threats acting independently so there are as many locations as sites.

Search Effort

Many of the historical surveys of insects including grasshoppers were done by sweeping which samples all vegetation including the foodplant of *H. alba*. The surveys were conducted throughout the prairie region and collections were made at a few hundred sites. Additional extensive survey aimed specifically at grasshoppers is described under **Population Sizes and Trends** where the information is used to interpret decline.

Between 2008 and 2010, targeted surveys for *H. alba* involved a single person (DJ) stopping at regular intervals to sample along highway and road transects E-W and N-S in Alberta. During July, sampling in search of previously unknown pockets of White Sagebrush was conducted by driving transects from Lethbridge south to the US border and north to Red Deer, and from Taber north to Viking (for a total of about 15 hours of actual sweepnet searching followed by 10 hours of closer sample bag examination). Sweep samples were also conducted. Three people (with field experience) searched with sweepnets in key sites (higher potential based on experience with in-field training), and subsequently visited sites in southern Saskatchewan and Manitoba in early August. After noting presence and abundance at some of the southeastern SK and southwestern MB surveys (Figures 5b & c), no further surveys and samplings were conducted.

The main area of interest in 2010 was southern and southeastern Saskatchewan, in areas where this species had been collected prior to 1980, and southwestern Manitoba. In the expected range, sampling was conducted by plant examination (typically 20—but up to 100—plants were sampled per site), and sweepnet sampling (38 cm diam.) in the vicinity of the plants (samples of 20 sweeps followed by an additional 50 sweeps at the same location if none are collected). Additional sampling (usually 50 sweeps per site, bagged) and examinations of plants were conducted at sites outside the normal range. Captured specimens were photographed and collected.

All directed searches involve searching the foodplant. As a result all habitat searched was potentially suitable. The foodplant has a sporadic distribution along roads and in rangeland and native prairie in protected areas. It is difficult to estimate the percentage of potential sites that have been searched, but it may be 1 percent. The locations of the recent directed searches are indicated in Figures 5b and c and discussed further under **Population Sizes and Trends**.

HABITAT

Habitat Requirements

Hypochlora alba inhabits relatively undisturbed dry mixed grass prairie of the Great Plains of North America, although in the U.S. portion of its range it has been reported in tallgrass prairie and sand prairie. All life stages feed primarily on White Sagebrush, a terpenoid-containing forb (Family Asteraceae) that is not eaten by other grasshopper species, and which is unpalatable to cattle. This very conspicuous foodplant is native to the prairie region of Canada and southward into much of the prairie region of the United States, but has spread elsewhere where it occurs in dry, open habitats such as roadsides and railways. In the prairie region it occurs in native prairies, pastures, rangelands, and uncultivated sites along roadsides, fencelines, streams, disturbed land, or shelterbelts. Other species of *Artemesia* are occasionally utilized as foodplants including Pasture Sage and Silver Sagebrush. *Hypochlora alba* is absent from large areas where the foodplant is present or even common, and occurs at a small proportion of the sites where the food plant is found. It occurs in generally low numbers in a narrow region near the US border through southern Alberta, Saskatchewan and Manitoba. Within this zone, it is always restricted to patches of the obligate food plant, which is usually a minor component of vegetation on dry grazing land.

Habitat Trends

In Canada some White Sagebrush habitat has been converted to Crested Wheatgrass (*Agropyron cristatum*) for cattle forage. Under conditions of heavy grazing, White Sagebrush is invaded by annual and perennial invasives and does not recover without fire. Drainage impediments such as dams, dugouts and reservoirs increased fourfold in southeastern Alberta between 1951 and 2001. This increase has altered hydrological regimes and degraded White Sagebrush communities. Habitat has also been recently fragmented by development, particularly oil and gas exploration (D. Johnson, pers. obs.).

Supporting a decline in habitat is the fact that collection records and literature suggested that this grasshopper was previously more common in Canada, particularly in the southeastern Alberta grassland (where it is now extremely rare or absent). Recent sampling has extended the range to the Great Sand Hills and Medicine Hat (Johnson and Olson unpublished data). There are also recent collections (2002-2005) from the Big Muddy in southern Saskatchewan and Grasslands National Park. At all of these sites, even where the host plant is abundant, relative abundance of *H. alba* is typically 1 per 10,000 grasshoppers collected by sweepnets or direct searching in dry mixed grass prairie.

Although the significance of decline in habitat can only be inferred by apparent general decline between 1980 and 2008, it does not seem an unreasonable conclusion, especially if habitat is considered in the broad sense of problematic weather conditions. In the eastern range there has been higher rainfall recently (Figure 6) and over the last few decades the climate has been cooler (unlike the late 70s and 80s, Figures 7 and 8).

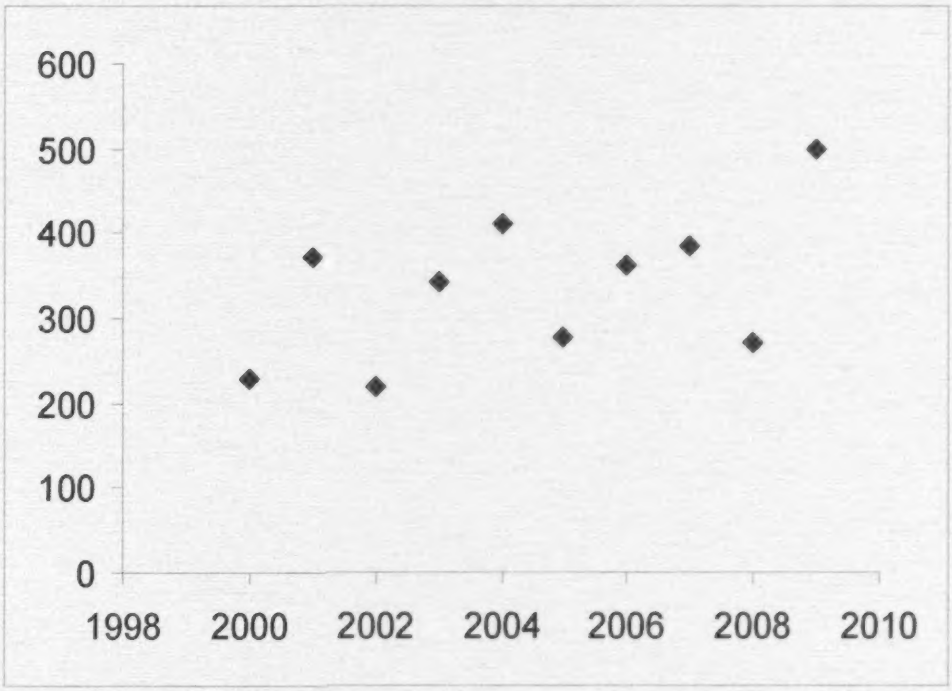

Figure 6. General increase in rainfall (mm) at Estevan during 2000 to 2009 (data downloaded from Environment Canada (2010; see Information Sources).

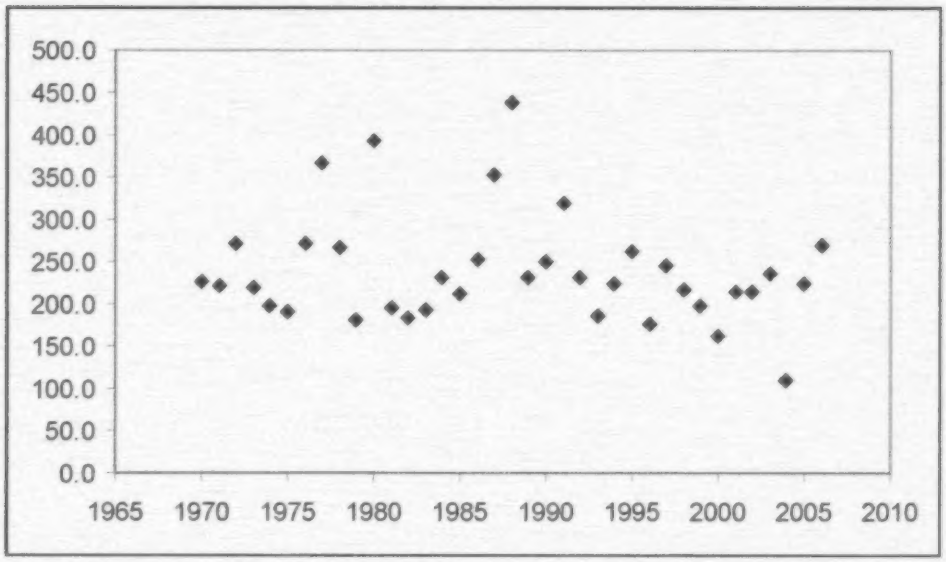

Figure 7. Degree-days (>12 C) at Brandon, Manitoba, accumulated to July 1. Degree-days were computed from the daily maximum and minimum temperatures (Environment Canada, 2010) using a sine function (or equivalent cosine function, which provides the same result).

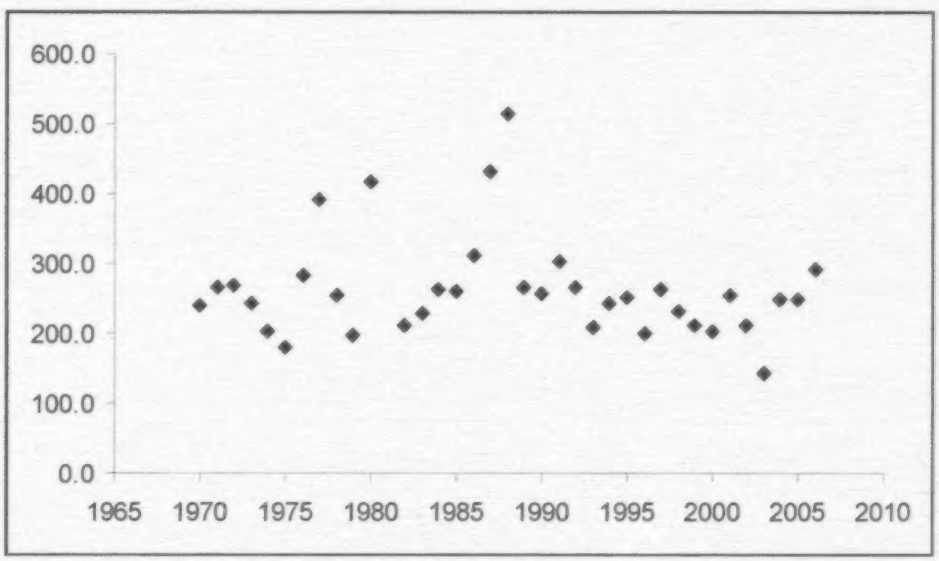

Figure 8. Degree-days (>12 C) at Estevan, Saskatchewan, to July 1. Degree-days were computed from the daily maximum and minimum temperatures (Environment Canada, 2010) using a sine function (or equivalent cosine function, which provides the same result).

An analysis of six habitat-related threats (see **THREATS AND LIMITING FACTORS**) leading to an overall threat impact of "medium" suggests continuing decline of habitat.

BIOLOGY

Life Cycle and Reproduction

Hypochlora alba overwinters as eggs in small egg pods laid near the surface of soil in close proximity to the food plant. The embryo overwinters with an incomplete degree of development and continues growth when soil warms. It hatches later than most other grasshoppers, typically appearing in mid-July in Canada. Growth proceeds through five immature stages, and adults are generally seen in August. By mid-August, populations are generally around 80% adult (D. Johnson unpublished data), although very low numbers and local microclimate mean this figure is not precise. The sex ratio is 1:1. As with other grasshopper species, behavioural adaptations have apparently allowed some expansion of potential geographic distribution. In late instars and the adult stage, they can be found sunning themselves by sitting on the food plant perpendicular to incoming sunlight, and often raising hind legs away from the body, a behaviour that raises the body temperature of grasshoppers (Lactin and Johnson 1997, 1998a, b).

Physiology and Adaptability

Little is known about the physiology of this species. Development has been outlined by Knutson (1982); it is known to be capable of consuming and utilizing general toxins found in the terpenoid-containing food plant; Smith and Kreitner (1983) note that trichomes of White Sagebrush can be found in the gut of *H. alba*. No studies concerning adaptability are known. This grasshopper species is not an agricultural pest, and other than its obligate relationship to the food plant, and some minor potential to accept other plant species, little is known about its general ecology and biology.

Dispersal and Migration

This species is flightless and does not move far from sites in which the food plant is found. It does not walk rapidly or readily. It is not known to migrate. However, females are reported infrequently to possess long wings that extend 2 to 3 mm beyond the end of the abdomen. Pfadt (1996) reports that H.C. Severin (1885-1964), a renowned student of grasshoppers at South Dakota State University, collected six long-winged females from the mixedgrass prairie of South Dakota in four different years: 1924, 1927, 1930, and 1931. The long wings suggest that at times this grasshopper has the ability to fly and disperse. It is not clear how occasional development of long wings affects dispersal, or whether it does at all.

Interspecific Interactions

As noted, *H. alba* is generally restricted to the obligate food plant, which is a minor component of vegetation on dry grazing land. Only rarely has it been observed feeding on other plants. It may be attacked by dipteran parasitoids, but no studies are available on the rates and timing of this host-parasitoid interaction. It is preyed upon by spiders, robber flies and birds, although protected to some extent by similar colouring to the plant, limited movement, and possibly some effects of food plant toxins on prey taste and predator response (D. Johnson unpublished data).

POPULATION SIZES AND TRENDS

Between 1980 and 2009 there were relatively few observations for a grasshopper with a relatively extensive range and no indication of rarity or fluctuation in the literature. All observations were of single individuals among large samples of grasshoppers, this suggesting decline. Among the examples of this are the following:

(1) *Hypochlora alba* was previously known from Onefour, Alberta (J. Hardman, pers. comm.), but was not found at this site during sampling between 1984 and 2002 (D. Johnson and C. Andrews, unpublished data). During an intensive study of the effects of grazing management on grasshopper populations and diversity, a total of 9,866 short-horned grasshoppers (Orthoptera: Acrididae) were collected from range and pasture during the multiple sampling dates during the summers of 2000 to 2006, including sampling in August (Johnson, Andrews, and Williams, unpublished data; for 2000-2006, N=2,769, 824, 1,085, 564, 2,031, 1,854 and 739, respectively). All 9,866 grasshoppers were sorted, frozen, and separated to species and age (there were no unidentified specimens). A total of 34 species of short-horned grasshoppers (plus about 10 rarer species of other Orthoptera) were identified from the collected specimens. Of the 9,866 acridids, none were *H. alba*. Other studies in the area were generally similar. Deliberate searching of areas of White Sagebrush also yielded no *H. alba* at Onefour during this time.

(2) In 2003-2004, more than 2,000 grasshoppers collected in range and pasture near Manyberries yielded no *H. alba* (D. Johnson, unpublished data).

(3) Sampling in Saskatchewan along road transects in 2002-2004 indicated only very low numbers, including around Grasslands National Park. Only one specimen, collected with permission, came from inside the West Block of the Park—this out of over 1,000 grasshoppers collected with sweepnets and identified to species in a preliminary study to prepare a species list (tentative list: Parks Canada, 2008). Field sampling in the East Block in 2007 yielded no *H. alba*, although this sampling was a general survey and no attempt was made to target the host plant of *H. alba*. Although it was previously known to be more common in this area, only two specimens were found at Big Muddy, Saskatchewan after extensive searching.

(4) In 2003-2004, B. Olson and D. Johnson surveyed the vegetation and Orthoptera at 68 sites in the Great Sand Hills, Saskatchewan during mid- and late summer. A total of 2,069 grasshoppers were systematically collected and identified to species and age. Several thousand additional specimens were examined in the field and discarded. A total of 49 species of Orthoptera were identified from these sites, but none were *H. alba*, even though White Sagebrush was confirmed at several of the collection sites, and Hoary and Pasture Sagebrush were present at 15 sites at least. One specimen was found southeast of the Great Sandhills sampling sites during examination of surrounding dunes and pastures.

(5) In 2007, B. Olson and D. Johnson surveyed an additional sample of more than 1,200 grasshoppers during the same study, and none were *H. alba*.

Sampling Effort and Methods

In 2010 in the expected range, sampling was conducted by plant examination (typically 20, but up to 100 plants were sampled per site), and sweepnet sampling (38 cm diam.) in the vicinity of the plants (samples of 20 sweeps, and then an additional 50 sweeps at the same site if none were collected). Additional sampling (usually 50 sweeps per site, bagged) and examinations of plants were conducted at sites outside the normal range.

Three focused sampling field trips were conducted in 2010 to assess current populations of *H. alba* in Canada. During July, sampling was conducted in driving transects from Lethbridge south to the US border and north to Red Deer, and from Taber north to Viking, in search of previously unknown pockets of White Sagebrush. Sweep samples were also conducted. The main area of interest was southern and southeastern Saskatchewan, in areas wherein this species had been collected in previous years, but in which they had declined significantly, in some cases below detection levels. This area was sampled in sunny conditions on August 8, with intended sampling days to follow if populations were low or nil (as in recent years). In previous years, this species was recorded as being found in an extended range of southern Alberta, Saskatchewan and Manitoba.

Abundance

No *H. alba* were found during any sampling in Alberta in 2010 and despite an extensive survey (Figure. 5c) only the border region of southeastern Saskatchewan produced *H. alba*. In Saskatchewan, collections along the Trans-Canada highway and within 2 miles north and south yielded no specimens, although many related grasshopper species (such as *H. viridis*) were abundant (all species together, densities ranged from 2 to over 50 per square metre). Driving from North Dakota into Manitoba and Saskatchewan underscored that the population remains in proximity to the national border. Sites in North Dakota had high densities of *H. alba*, often several per plant more than had been observed in previous years. Populations at the Manitoba-Saskatchewan-North Dakota border were low but detectable at 12 out of 15 sites with White Sagebrush. A zone along the Souris River and partway to Estevan was low in density, but previously high. However, the populations south and west of Estevan had not only increased, but now exceed any indication from observations in the past 20 years.

It is estimated, based on extrapolation of numbers within designated areas, that there are up to 1000 individuals on a typical 1000 ha site and that there are over 100,000 in currently known sites in Canada.

Fluctuations and Trends

A reasonable hypothesis for the apparent increase of populations is that *H. alba* and White Sagebrush populations increased under recent years of environmental conditions that were cooler and moister than the preceding period (Figures 6, 7, 8). Populations near Great Sand Hills, Saskatchewan, and Medicine Hat, Alberta, are very low and scattered but may also increase given the number of small patches of White Sagebrush observed along roadsides and in pastures.

Rescue Effect

No information is available on a possible rescue effect resulting from a scenario of movement from nearby sites in the United States. Very low populations in Canada have recently increased *in situ*. No data are available to test a hypothesis of long-distance movement, but movement of more than 500 m (and subsequent relocation) by this species within one year is considered to be very rare. The species has obviously moved north in the past, given the post-glaciation history of the grassland ecoregion, but this is a slow process for a flightless species that is dependent on one main food plant with a patchy distribution.

THREATS AND LIMITING FACTORS

A number of threats exist for which information is incomplete.

Hypochlora alba is suspected to be intolerant of disturbances related to "improved" management of grazing land that would reduce the occurrence of the food plant. Grazing may benefit this grasshopper, because White Sagebrush is unpalatable to cattle, and grazing reduces competition from other plants. The density of White Sagebrush is generally low on the Canadian Prairies. Fluctuations in the density and growth of the host plant could result in periodic reductions in abundance of this species. Under this condition, *H. alba* could take extended periods of time to recover and repopulate the former range, because it is small, flightless, less active than other grasshoppers, and hatches relatively late in the season. However, this species may benefit from warmer spring and summer conditions if precipitation and plant reproduction are sufficient to maintain the density and seasonal availability of the food plant. *Hypochlora alba* is probably not resistant to prolonged heat and drought, because the integument of this delicate grasshopper is not thick or robust, and the abdomen is not protected by heavy forewings (tegmina) as in some other prairie grasshopper species.

Potential threats are summarized as follows:

1) Weed control or range and pasture improvement could be devastating. This species depends on the food plant. Conversion to tame pasture with Crested Wheatgrass and removal of White Sagebrush would eliminate populations.
2) Climate change projections for the Prairies indicate warmer and moister conditions, but occasional dryness could decrease populations because these grasshoppers do not seem well equipped to deal with such conditions. The potential threat posed by climate change remains unknown.
3) Pesticide use and drift from adjacent areas will eradicate the *H. alba* from small local pasture populations.
4) Dams, reservoirs, irrigation, cropping, and other agricultural activity may change hydrology maintaining the White Sagebrush and also eliminate the plant and subpopulations. Such agricultural activities increased four times between 1950 and 2001.
5) Oil and gas exploration, roads, etc. and other developments on the landscape will isolate a flightless species and reduce habitat.
6) Heavy grazing leads to takeover by invasive plants eliminating the White Sage.

Although there is little definite information on these threats, it seems reasonable to conclude that over a 10-year period all operate and all affect 1-10% of the total population (scope = small), and also that the damage is at least a 1 - 10 % reduction to that portion that is affected (severity = slight). This leads to an overall threat impact of medium (using Master *et al.* 2009).

PROTECTION, STATUS, AND RANKS

1) Legal Protection and Status
   COSEWIC assessed this species as Special Concern in November 2012. Currently, this species has no protection or conservation status.
2) Non-Legal Status and Ranks
   There is no special status for this species or its food plant.
3) Habitat Protection and Ownership.
   There is no special status of the general habitat (pastures and roadsides), unless they occur in parks or protected areas. In the main current range, this would be mainly the Grasslands National Park.

The following ranks apply: G5 (last reviewed in 2000; USA- N5; Canada N3N4 (last reviewed 2012); MB and SK SNR.

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

Craig Andrews, retired Research Technician, Lethbridge Research Centre

Grasslands National Park staff. A list of Orthoptera found in Park 2003-2005 by D. Johnson is available on-line: http://www.grazingbiodiversity.org/species.shtml

Jeff Keith, Biologist/Coordinator, Saskatchewan Conservation Data Centre SKCDC. http://www.biodiversity.sk.ca/

Lethbridge Research Centre (LRC) Insect Collection Orthoptera Section list (the current curator of the overall museum is Dr. Bob Byers)

Brian Olson, entomologist, insect collector and retired school principal, Hazlet, SK; working in Great Sand Hills, SK

Dr. Ray Poulin, Curator, Royal Saskatchewan Museum, Regina, SK

Dr. Robert Randell, Curator, Entomological Museum, Saskatoon, SK. Also previous discussions.

Dr. Walter Willms, Senior Research Scientist, Onefour Research Station, AB, and Lethbridge Research Centre

Information provided by experts on this topic, before 2010:

V. Vickery; previous request for information on this species, during personal meetings and contacts in the 1990s. Before the current survey (2010), the report writer examined the Canadian National Collection, Orthoptera section, for specimens of this species, during 2004-2005, with the approval of Dr. John Huber and Dr. Yves Bousquet (no recent specimens). The report writer also expresses thanks to Dr. Dan Otte (Curator and Chairman, Department of Entomology, Natural History Museum, Philadelphia) for the opportunity to examine the Natural History Museum Orthoptera collection.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Dr. Dan L. Johnson is currently a Professor of Environmental Science and Canada Research Chair in Sustainable Grassland Ecosystems in the Department of Geography, University of Lethbridge, where he has taught Biogeography, Geographic Information Systems, Geographic Data Analysis, Ecosystem Modeling, Environmental Science courses, Environmental Science for First Nations Transition, and Experimental Design and Data Analysis. His current research concerns investigation of the activities and relationships of organisms in the land and water of Canadian grassland ecosystems, including determination and amelioration of environmental impacts, to allow environmentally sustainable development. He has published over 90 scientific journal articles, plus book chapters, maps, reports and other science-related publications, but also writes for the public, including "The Public Professor" column in the Lethbridge Herald, and published a recent book of photographs for non-specialists to identify the 25 most common species of grasshoppers in crops on the Canadian Prairies. Previously, he served for over twenty years as a research scientist with Agriculture and Agri-Food Canada Research Branch. He also conducts research on alternative pest management methods, including microbial control. Among other things he is recognized as a world expert on grasshoppers and locusts, and chaired and organized the world meeting on this topic (Orthopterists' Society, Canmore, Aug 14-19, 2005). He has served overseas on short assignments for the US Agency for International Development, the Canadian International Development Agency, CAB International, and industry, and he has led

over 50 scientific projects. He served as President of the Entomological Society of Canada, and in several editorial and society executive positions, and as a member of three Canadian Species at Risk Recovery Teams (Burrowing Owl; Western Spiderwort; Yucca and Yucca moth). His university degrees are in Biology (BSc., Magnis cum honoribus, University of Saksatchewan), Plant Science and Animal Resource Ecology (MSc. and PhD, University of British Columbia, Institute of Animal Resource Ecology).

COLLECTIONS EXAMINED

The report writer examined insect collections at the University of Lethbridge and the Lethbridge Research Centre; he was also in contact with private collectors and the Royal Saskatchewan Museum curator (Ray Poulin), and early in the study, with the curator of the Insect Museum at the University of Saskatchewan (Dr. Bob Randell) as noted in the "Authorities Contacted" section. Collections at the University of Lethbridge consist only of those of D. Johnson, the author. Recent collections from in and around the AAFC Onefour Research Substation, Onefour, Alberta, by C. Andrews and D. Johnson were examined, as well as several years of collections by C. Andrews alone.

Thirty specimens (now pinned and dried) were collected by the author in 2010 from sites where this species was recently absent or very low in abundance. These are currently stored in insect cabinets at the University of Lethbridge. Specimens will be provided to museums that COSEWIC designates. New high-resolution photographs of this species were obtained during 2010, with better quality than previously possible.